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Testing the Ability of Subsistence Farmers to Use Seasonal Climate Forecasts: A Participatory Approach in Zimbabwe

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I. PRELIMINARY MATERIALS

Project Abstract

Currently at NOAA and other governmental and intergovernmental agencies and research institutes, scientists are working hard to develop and apply seasonal climate forecasts. In large part, these forecasts have been made possible by an ever improving understanding of dynamics between oceans and the atmosphere, such that with data about ocean temperatures (which change relatively slowly over time) one can make predictions about weather patterns in particular places around the world, many months in advance. Ideally, these forecasts would allow decision-makers in all kinds of climate related sectors to plan ahead, and improve their decision-making. Organizations such as the NOAA-funded International Research Institute for Climate Prediction (IRI) are working to make such forecasts useful to a variety of decision-makers. They are paying a great deal of emphasis to users in developing countries, where traditionally people have had little access to high quality scientific information, and where many people's lives are highly vulnerable to climate.

Past research has shown that many potential users of climate forecasts do not use the information as much as scientists had hoped, even though it is likely that using the information would greatly improve their chances for improving their quality of life. This is especially so of small-scale farmers in developing countries. One of the first countries where scientists attempted to make climate forecasts both widely available and user-friendly was Zimbabwe. Nevertheless, during the last major El Niño episode—1997-98—it appeared that few small-scale farmers used the information. There are several different hypotheses about why this is so: farmers do not learn about the forecasts; farmers do not understand the forecasts, especially forecasts that are probabilistic; farmers do not trust the forecasts, especially after past forecasts have proven less than accurate; farmers do not trust the people telling them the forecasts; the forecasts come at the wrong time to be useful to the farmers for their actual decisions; the forecasts give farmers the wrong kind of information; the forecasts are not accurate enough to be useful; the forecasts do not

include reference to local and traditional indicators with which farmers are familiar; or, there are no practical decisions that farmers could make differently because of the forecasts. To best improve future forecast development and communication practices, it would be valuable to learn which of these hypotheses is in fact an obstacle to successfully using the forecasts. The goal of this research is to test these various hypotheses.

In order to test any hypothesis about a cause-effect relationship between two variables, it is necessary to analyze multiple observations in which there exists variance in the independent variable. This fundamental need guides the research methodology for this project. First, we deliberately introduce variance into the system we are studying in a way that does not make any members of that system—farmers in Zimbabwe—worse off. We do this by trying to "improve" one or more of the independent variables, primarily be taking the time to explain the forecasts in a much better way than has heretofore occurred. This takes place in a village "forecast workshop" that lasts one entire day, and which a number of farmers from the community attend. We repeat these workshops on an annual basis, in a number of villages throughout the country. These workshops typically occur in September, after the official forecast has been released but before the planting season has begun. Second, we measure the resulting variance in our variables through a household survey instrument. This takes place in April, at the end of the growing season. These two activities—conducting workshops and administering and analyzing surveys—are the primary activities of this research. We discuss these two activities in the remainder of this progress report. We also discuss other work areas within the project: writing, participation in meetings, and additional research.

Objective of Research Project

There are both theoretical and applied objectives of this project. The theoretical objectives are within the disciplines of behavioral economics and geography, and relate to the use of information. What individual factors promote the effective and timely use of new information for problem solving? What institutional factors overcome the individual barriers? How can information content be structured so as to promote effective use of the information? These questions relate not just to the use of climate forecasts, but really all types of information related to decision-making under conditions of uncertainty, by both individuals and policy-makers. The second objective is related to the field of climate forecast communication, and that is to document the obstacles to forecast use by subsistence farmers, and to test the hypothesis that these obstacles can be overcome through strategic communication practices.

Approach

The main approach has been experimental. The central piece of work in the project is a controlled experiment occurring over three years. Our control group is farmers who receive forecasts through the standard channels, such as the radio. Our treatment group is farmers who attend workshops, where they learn more information about the forecasts, of a different character. By then observing how these two groups react to the forecast, we can tell whether the particular methods used in the workshops made a significant difference. In the process of surveying all farmers, both in the control and treatment groups, we can gain additional insights into their decision routines, and how forecasts fit into those routines.

In terms of specific theory tested, that derives from the behavioral economic literature, in terms of barriers to effective decision-making arising out of the misapplication of engrained decision-heuristics. We are unconvinced that that farmers are making bad decisions, and yet we are also

confident that there are places where their decisions could be improved, once one understand how the procedure of decision-making influences their choices.

Description of matching funds

Boston University Department of Geography. Boston University provided startup funds for this project in the amount of $15,000, during 2000 and 2001. This allowed for the making of important contacts prior to the receipt of NOAA funding.

Social Science Research Council, Program in Applied Economics. 2003 Risk and Development Field Research Grant ($2,600). This has supported the research assistant, Pablo Suarez, to conduct additional fieldwork in Zimbabwe, as well as complementary fieldwork in Argentina, necessary for his PhD dissertation.

ProVention Consortium, 2003 Applied Research Grant for Disaster Risk Reduction ($3,900). This has allowed Pablo Suarez to attend workshops on disaster risk reduction and management in Austria and Japan.

II. INTERACTIONS

With decision makers

Since the purpose of the project was to test the use of information by decision-makers, we have had extensive interactions, beginning with the farmers themselves.

Subsistence farmers: Each year we held one workshop in each of the four locations in Zimbabwe (Mhakwe, Tiya, Mkoka-Matopos and Mafa). Between forty and sixty farmers participated in each workshop (more than 200 farmers per year in total). In addition to the workshops participants, this field project has impacted a large number of farmers in the area where the events were held by way of informal communication among farmers.

Zimbabwe Agricultural Extension Service (AREX): Interactions included feedback regarding workshop format and logistics, revision of survey instrument, assistance in guiding dialogue on response strategies during participatory workshops, as well as detailed explanation of seasonal forecast. Contacts included the AREX coordinator for the Chimanimani District, Mr. Mughani, and the following field officers: Ms. Olinda Tuso (Biriwiri Village), Ms. Loice Mubako (Bumba Village), Mr. Limon Ncube (Lupane District) and Mr. Dube Ndodana (Ken Maur Village).

Local elected officials and traditional leaders: Assistance in inviting farmers to workshops and arranging logistics, key role in workshop discussions regarding responses to forecast. Mr Watchy Sibanda (Ward councilor, Mkoka-Matopos) and Mr. Mukazhi (Ward Councilor, Mhakwe). Chief Moyo (Mkoka-Matopos) invited half a dozen of his colleagues from several communities in Matabeleland to the workshop.

Schoolteachers: Workshops were held in schools most of the time, and benefited from the valuable participation of teachers and schoolmasters. Mr. Mukwambo and Mr. Gwavuya (Tiya), Mr. Kaneta, Mr. Mandzidzidze and Ms. Majeje (Mhakwe), Ms. Bhebhe and Mr Sibanda (Mkoka-Matopos), Mr Sibanda, Mr Kudakwashe and Ms Dube (Mafa). In addition, we assisted each of the schools in establishing a rainfall monitoring program (rain gauge and log book) for their students to oversee.

University of Zimbabwe: Our local collaborator, Ms. Chiedza Gwata, teaches at the University's Department of Agricultural Economics. Many of her graduate students, who will be expected to move into the field of agricultural extension, have participated in the project as enumerators or as assistants in the decision-making experiments.

NGOs: Near the end of the project, we collaborated with the Regional Environmental Organization of Zimbabwe (ZERO) to organize a workshop with key stakeholders to disseminate our findings. This was held at the offices of the IUCN

With climate forecasting community

The project has led to sustained communication with members of the forecasting community in order to learn about forecasts and climatic conditions in Zimbabwe, to share results and lessons learned from participatory workshops, and to seek feedback regarding publication manuscripts.

Southern Africa Regional Outlook Forum (SARCOF): We have actively participated in the meetings in Harare (2002) and Lusaka (2003), interacting with forecasters from Southern Africa, the US and Europe, as well as local forecast users from different sectors. The interactions took the form of presentations (two per event), active engagement in discussions, and in the case of the Lusaka event, joint work with media representatives to "adapt" the SARCOF statement to a language more suitable for mass media.

Drought Monitoring Centre for Southern Africa: We have had extensive discussions with Emmanuel Dlamini, of the Harare DMC office, concerning the products of the SARCOF meetings, as well as methods and tools for climate forecasting. Mr. Dlamini also participated in an expert survey we conducted, at the UNFCCC Ninth Conference of the Parties (Milan, Italy), on the communication of uncertainty related to climate prediction.

International Research Institute for Climate Prediction (IRI): Interacted via email and in person with researchers at IRI, particularly Maxx Dilley, James Hansen, Simon Mason. We gave a presentation of our findings at the IRI in July, 2005.

Coordination with other NOAA projects and researchers

With Emma Archer, in South Africa, we have worked at developing a common survey instrument,that would allow comparisons of our findings. This involved a site visit to her location in the Limpopo Province of South Africa, as well as discussions with her in Zimbabwe and in Cape Town.

We have reviewed proposed work by James Hansen and Guillermo Podestá and have had several NOAA researchers review our proposed work and findings (Jennifer Phillips, Guillermo Podestá, Corrinne Valdavia). We have had discussions with Paul Kirschen and Carla Roncoli about the design of their methodology in Burkina Faso, in order to improve our own methodology. In compiling literature, we have kept in close contact with these other NOAA researchers.

We have had discussions with Maxx Dilley concerning the organization of the September 2004 SARCOF meeting. We plan on attending the meeting, and in working with him and others at the Harare DMC to assist in organizing the meeting.

With Colin Polsky, we have organized a panel session at the Open Meeting of the Human Dimensions of Global Environmental Change Research Community (Montreal, October 2003),

examining adaptive capacity and the role of climate information in the improvement of adaptive capacity. Also at the Open Meeting in Montreal, we have participated in the panel session organized by Nancy Beller-Simms and Caitlin Simpson on the use of climate forecasts for decision making.

III. ACCOMPLISHMENTS

Research tasks accomplished

Each year of the project we conducted participatory workshops in four communities in rural Zimbabwe. While the main purpose of these workshops was to communicate the scientific forecast for the coming season and to explicitly test the benefits of providing more, rather than less, information, we structured these events in a way that tried to show respect for traditional forms of knowledge, and to facilitate the exploration of response strategies on the part of subsistence farmers. These workshops occurred as soon as possible after the September SARCOF meeting, typically the second or third week of September. This was sufficiently far in advance of the planting season—usually mid-October through December—to allow farmers to use the information gleaned in the forecasting workshops to purchase different farming inputs, especially different varieties of seeds. While we organized and facilitated the workshop, we also counted on the local agricultural extension officer, as well as local leaders—schoolteachers, village chiefs, village elders—to participate actively and share their knowledge. Between forty and sixty farmers—a mix of men and women—attended each workshop. The workshops lasted most of a day, and gave participants an opportunity to learn and ask questions about not only the official scientific forecast, but also background information (such as what El Niño actually is), sources of uncertainties in the forecast, and how the forecast compares with the village leaders' interpretation of local and traditional indicators.

At the end of the rainy season (usually April), a survey was conducted in each community to evaluate the impact of the forecast on decision making, both on farmers who attended the workshop and farmers who didn't. Approximately three hundred farmers were surveyed each year.

The survey was thirteen-pages long, and designed to gather data on such issues as demographics, assets, perceptions of risk, farming practices, access to and understandability of climate forecasts, and responses to the forecast (both desired and actually implemented). Graduate students from the University of Zimbabwe assisted as enumerators and in data entry. Fieldwork for the surveys took three days in each of the four villages, with enumerators walking from household to household to interview respondents personally. The local collaborator, Chiedza Gwata, had primary responsibility for supervising the enumeration, with assistance from Bulawayo resident Alan Eson. We, in turn, worked with them to make sure that the survey is capturing a representative sample, and in continually refining the survey for clarity and precision.

As behavioral economists, we were particularly interested in potential cognitive and behavioral obstacles to the rational use of climatic information. In other words, it is possible that farmers (and forecasters) will be subject to biases that result in sub-optimal results at the individual or collective level. In particular, we were interested in examining whether two behavioral factors could influence the uptake and use of climate information: present-biased discounting, and heuristics of trust generation. To examine each of these issues, we engaged in the standard behavioral economic practice of conducting decision-making experiments. These were games that participants played, in which they made a series of decisions under highly structured incentive structures, such as small cash prizes. We conducted experiments both in the cities of Harare and

Bulawayo, and in the four village fieldsites, during the May 2002, September 2003, and September 2004 trips. The results are described below.

Elaboration of key findings

There were several different sets of findings made in the project, each of which we elaborate below. The first of these sets of findings were in direct answer to the original questions put forth in the project, while the other two sets of findings were additional results, not originally proposed but nonetheless interesting and important.

Forecast Use

The first set of findings was the core of the project. We examined three main issues: (1) what factors limit farmers' use of the seasonal climate forecasts? (2) Are farmers more likely to use the forecasts if they are communicated in an appropriate participatory manner? (3) Do farmers who change their decisions in response to the forecasts—i.e. use the forecasts—benefit from having done so. The first of these issues is very similar to issues examined in other projects throughout Africa, and demands qualitative answers, based on interactions with farmers either personally or through surveys. The second is an issue touched on by other projects, but one which we answered quantitatively, making use of our study design in which we held pilot workshops. The third, to our knowledge, is a question to which this project has generated the first results.

We identified six important factors that limit farmers' use of the forecasts. The first of these is credibility. In many cases, farmers simply do not trust the forecasts to be accurate. This has especially proven the case following instances in which the forecast appeared to be wrong, such as happened in the mid-1990s in Brazil, and in the late 1990s in Zimbabwe. Scientists and other people communicating the forecasts can augment or dampen the credibility factor based on how they communicate the forecast. If they communicate it as being deterministic, and then it proves wrong, then trust in the forecast is likely to fall. If they communicate it in probabilistic terms, then people will rightly understand that a failure of the most likely outcome to occur was still within the forecast's range of potential outcomes, and they will not feel lied to and manipulated. The second factor is legitimacy. Farmers have certain types of traditional knowledge that they feel culturally obliged to listen to, and to the extent forecasts conflicts with these types of knowledge and belief, then the forecast will be seen as illegitimate, and not to be used even if it is believed. Legitimacy can be enhanced by presenting the forecast as similar to traditional knowledge, i.e. based on personally observation and analysis by people. The third factor is scale. The forecast has to present information that is relevant to the temporal and geographical scale at which farmers operate. Downscaling information is often difficult or even impossible, but where it is possible to downscale it, it will be most useful. The fourth factor is cognition: farmers have to understand the forecasts. If, for example, the forecast is communicated in probabilistic terms, so that credibility does not suffer should the most likely outcome fail to occur, there is the chance that farmers will not understand the meaning of the probabilities conveyed. Likewise, farmers need to be able to understand how this information related directly to the choices they face. The fifth factor limiting forecast use is the set of procedures farmers already have. For example, many farmers do not purchase their own seeds, but rely on friends and family in the city to purchase them, where the prices are lower. Even if the farmers want to use the forecast, this procedure will stand in the way. Over time, farmers may adapt their procedures to allow for the use of the information. The sixth factor is the set of choices farmers are actually able to make. These choices must be continuous enough to allow for the incorporation of small pieces of information at the margin. If the only choice farmers have is to plant or not to plant, then it is unlikely that the information will be of sufficient importance to change that choice.

The second finding related to the benefits of a participatory communication strategy. Three hundred and sixty seven respondents in our survey had received information about what to expect for the coming rainy season, via a workshop or another medium, and of these 57% reported making different decisions because of the seasonal climate forecast. The two main ways that farmers reported using the forecast was by altering the time of planting (50% of farmers who reported making a change), or by planting different varieties of crops (40%). In 2002, many farmers planted a greater proportion of their fields with short season varieties, and planted them early, to take advantage of November rains and give themselves the opportunity to replant. In 2003, many farmers staggered their planting times, and planted a greater proportion of their land. None of personal demographic variables, including farmer training, education, and household assets, showed a significant relationship with reported changes made in response to the forecasts, and we omitted them from the subsequent analyses. People attending the workshops, however, were significantly more likely to report using the forecasts than those who heard of the forecast through other means, in the two communities where we had an unbiased sample of workshop attendees (Mafa $\chi^2(1) = 4.12$, $p = 0.04$; Mkoka $\chi^2(1) = 14.9$, $p < 0.001$). Figure 1 shows the results for these two communities, aggregated across two years of the survey, 2003 and 2004.

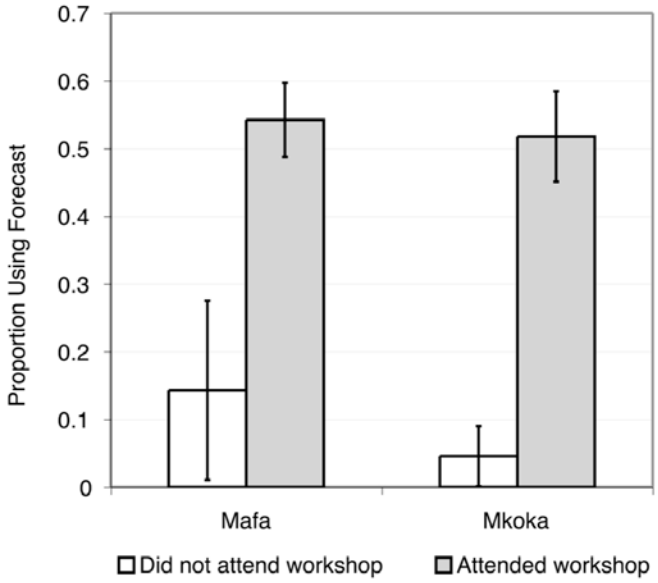

Figure 1—Effect of workshop attendance on forecast use

The third finding was that farmers who used the forecast to change their decisions did significantly better—enjoyed higher yields relative to their own historical averages—than those who did not. To examine this from the data which we gathered, we constructed a relative harvest index (*RHI*) that expresses the farmers' harvest relative to their historical baseline range:

$$RHI_i = (A_i - B_i) / (G_i - B_i)$$

where $(A_i - B_i)$ is the difference for farmer *i* between the *actual* harvest in the current year and that of a typical *bad* season, and $(G_i - B_i)$ is the range between typical *good* and *bad* seasons. *RHI* takes on a value of 0 if the farmer's *actual* harvest matched the estimate of a typical *bad* season harvest, and 1 if the farmer's *actual* harvest the estimate of a typical *good* season harvest. *RHI* can also take on values outside of this range, if the *actual* harvest falls outside of the estimated

range of *bad* to *good* years' harvest. Figure 2 shows the average value for this indicator across the four study sites, in each of two years for which we analyzed data. In the first year, which as an El Niño year, the difference was not significant. In the second year, there was a significant difference. There was also a significant different aggregating the two years.

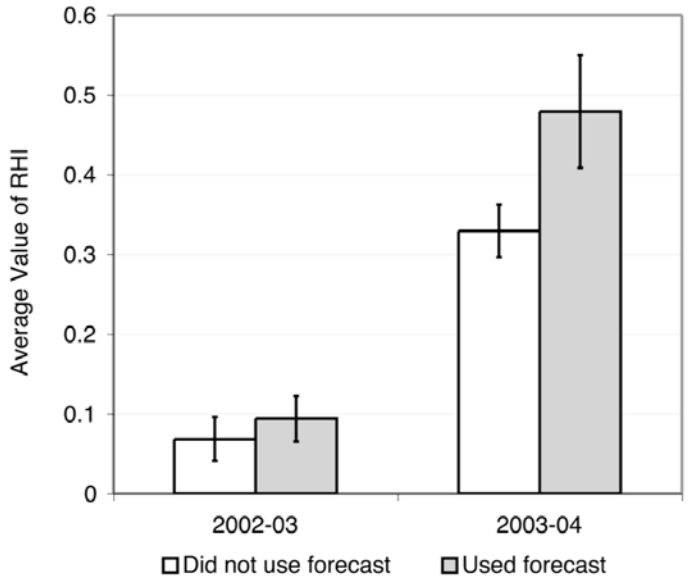

Figure 2: Effect of forecast use

Trust heuristics

The second set of findings related to heuristics people use to generate trust in information and advice they receive. We wanted to examine whether particular conditions of information transfer could affect this level of trust. In particular, we were interested in seeing whether communicators who had a stake in the outcome—i.e. they would benefit when the farmers themselves enjoyed higher harvests—would enjoy higher levels of trust. This is something that has been observed qualitatively, although it has been impossible in previous studies to hold the quality of information constant. We also wanted to compare this higher level of trust with that enjoyed by communicators who were paid by the decision-makers for the information. Previous psychological studies have shown that paying for information increases the likelihood that it will be used.

To study these questions, we developed an economic experiment, in which participants played to rounds of the Monty Hall three door game, a common counter-intuitive puzzle. We played the game under different conditions of advice provision. Some participant received no advice. Others received advice, but there were no obvious incentives for the advisor to communicate good advice (we called this condition *simple advice*). Others received advice, and the advisor would win the same prize as the decision-maker (*aligned incentives*). Others received advice if they chose to pay for it (*prepaid advice*). The advice that was offered was the same in all conditions.

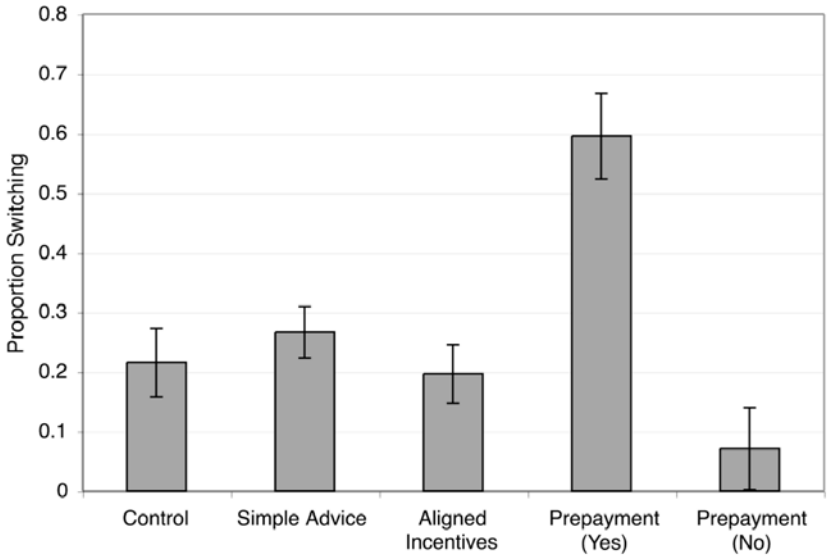

Figure 3—Use of advice in first round of game

Figure 3 shows that in the first round of the experiment, our hypothesis of increased us of advice given aligned incentives did not bear out, and indeed, except for the prepayment condition, there was no observed effect on behavior of giving advice at all. However, in the second round, we did observe significant benefits among those who were in the aligned incentives group, especially when the advice they received in the first round was in fact correct, i.e. generated a winning outcome (observed switching—the advice—worked). This demonstrates that aligned incentives may be an effective way of increasing trust in advisors, especially under conditions where sometimes the advice proves to be helpful, and yet sometimes it does not.

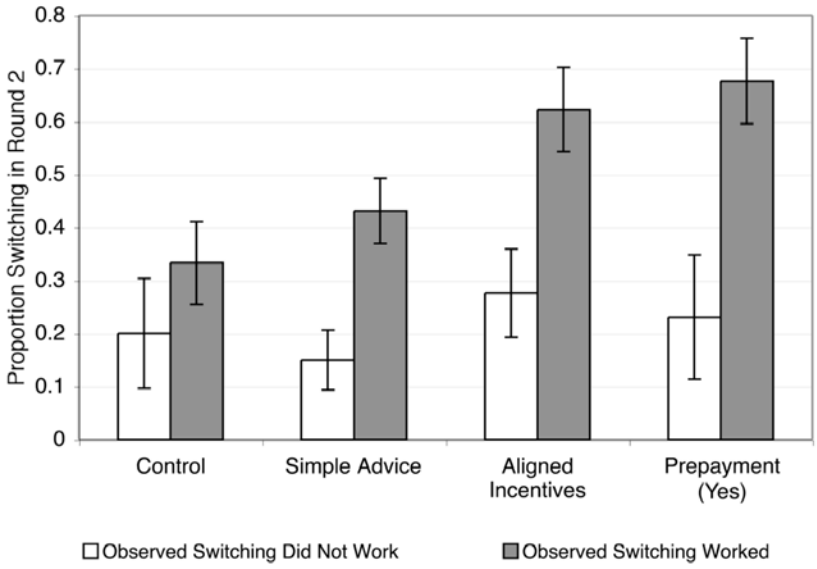

Figure 4—Use of advice in second round of game

Discounting

The third set of results relates to the use of present biased discounting, and the relationship of present biased discounting to food insecurity. To test for this, we conducted an experiment in which people had the opportunity to receive a certain amount of maize meal—10 kg—in two weeks time. They could then make bids to receive a lesser amount immediately, with the lowest bids being accepted, i.e. they received their bid amount immediately, and forwent the 10 kg in the future. A second auction was also conducted: they had the opportunity to receive 10 kg of maize in approximately one year, but could make bids to receive a lesser amount of maize two weeks earlier, with the lowest bids again being accepted. In each case the difference between 10kg and the amount bid was the equal to the cost of waiting two weeks, or the discount factor. By subtracting the discount factor for the second auction (maize to be received in a year) from the discount factor for the first auction, we were able to estimate the immediacy effect: the discount factor associated not with two weeks in general, but two weeks right now. This is known in the behavioral economics literature as present bias. Present bias can lead to counter-productive decision-making, including procrastination and an unwillingness to make long-term investments, and it has been hypothesized that it is an important factor in development and climate change adaptation.

Our experimental results showed significantly different patterns of present bias depending on the level of food security in the community. While the average present bias was not different between the different communities, in the less food secure villages there was significantly greater variance in present bias, suggesting less consistent decision-making with respect to time.

List of Publications

Patt, Anthony, Hannah Bowles, and David Cash (in press). Mechanisms for enhancing the credibility of an advisor: prepayment and aligned incentives. In press at *Journal of Behavioral Decision Making*.

Cash, David, Jonathan Borck, and Anthony Patt (in press). Institutions for linking research to decisions: a comparative analysis of ENSO forecasting systems. In press at *Science, Technology, and Human Values*.

Patt, Anthony (in press). Trust, respect, patience, and sea surface temperatures: useful climate forecasting in Zimbabwe. In R. Mitchell, W. Clark, D. Cash, and F. Alcock (eds.), *Global environmental assessments: information, institutions, and influence*. Cambridge: MIT Press.

Patt, Anthony, Pablo Suarez, and Chiedza Gwata (2005). Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe. *Proceedings of the National Academy of Sciences of the United States of America* 102: 12673-12678.

Grothmann, Torsten and Anthony Patt (2005). Adaptive capacity and human cognition: the process of individual adaptation to climate change. *Global Environmental Change* 15(3): 199 – 213.

Suarez, Pablo (2005). *Decision-making for reducing vulnerability given new climate predictions: case studies from Metro Boston and rural Zimbabwe*. PhD Thesis, Boston University.

Suarez, Pablo and Anthony Patt (2004). Caution, cognition, and credibility: the risks of climate forecast application. *Risk, Decision and Policy* 9: 75-89.

Patt, Anthony and Chiedza Gwata (2002). Effective seasonal climate forecast applications: examining constraints for subsistence farmers in Zimbabwe. *Global Environmental Change* 12: 185-195.

IV. RELEVANCE TO FIELD OF HUMAN ENVIRONMENT INTERACTIONS

Furthering the field

The project has furthered the field of understanding the use of climate related information in decision-making in three essential ways. First, and most importantly, it has shown that over successive years subsistence farmers can benefit simply from using seasonal climate forecasts. This is something that other research has yet failed to show at this level of detail. It is true that in Latin America in the 1990s, where seed stock was distributed that was appropriate for the forecasted quantity of rain, national harvest levels did rise. However, in this case, it is difficult to tell whether this was a function of the quality of seed stock distributed, the fact that distributing the seeds free of charge left farmers with additional resources t o purchase other inputs such as fertilizer, or whether it was indeed the simple use of the forecast information that resulted in the increased yields. By contrast, our results indicate that farmers benefited significantly from using the forecasts *solely as a function of the use of the information*. That is, even without additional assistance to apply the information, they made different decisions that benefited themselves. While these results may be limited to the growing conditions of Zimbabwe, they are important in being the first step, in terms of showing that it is possible to measure the difference on the individual level.

The second main contribution to the field is showing that it is vitally important how the information is communicated. The two most popular means for disseminating forecast information is via pre-existing networks of agricultural extension workers, and via the radio. While these methods are important, each has its limitations. First, the way that extension services often function, the pace at which information flows from national to local levels is often quite slow, requiring several weeks or even months for the transmission to occur. It has been observed in Zimbabwe that by the time farmers received forecasts from their local extension officers, it was too late: they had already made their critical decisions, such as what crops to buy. The second method, radio, is much faster. However, it does not allow for interaction by farmers, which can be especially important in the case of probabilistic information that is difficult to understand. Moreover, it can be difficult to tailor the message communicated by radio to the local community, unless small community radio stations serving a small geographical area do its dissemination, something done in the RANET project. What our results show is that when the ability for farmers to interact is combined with timely information, as we did in our workshops, then the rate of use of the forecasts rises significantly, often by a factor of more than two. We believe that the template for community workshops that we developed in this project could be scaled and implemented on a much wider basis. Importantly, though, we have shown that it can make a difference.

The third main contribution to the field is in terms of examining several important theoretical issues, in particular trust and discounting. We have shown that the findings on these issues made in more developed countries are also to be found in lesser-developed countries such as Zimbabwe. Moreover, conditions of food insecurity may exacerbate preexisting biases, in such a way as to influence the extent to which people decide to use climate information to make more intelligent investments and cropping decisions. While our experimental findings were published

in the behavioral literature, we believe that they point the way to doing more such experiments in developing countries like Zimbabwe.

Building upon previous work

In his PhD work, the PI received one year's funding via the Center for the Integrated Study of the Human Dimensions of Global Environmental Change at Carnegie Mellon University. During that period of time, he initiated research in Zimbabwe on the use of seasonal climate forecasts. The results from that funding suggested that farmers were capable of understanding and working with probabilistic information. Those results suggested to the PI that it was worthwhile attempting a more detailed study, in which one would examine whether farmers would apply and benefit from probabilistic information in their actual daily farming decisions, rather than simply in an abstract experimental format. That was the birth of this project. The first two years of workshops were held in Zimbabwe in 2000 and 2001, with funding from Boston University. This project extended that by holding the workshops for an additional three years, and by combining them with surveys, through which the main data was collected.

Specific contributions

The project has made specific contributions to the following areas: economic value of climate forecasts, matching new scientific knowledge with indigenous knowledge, and ways of communicating uncertain information. As to the first, this study shows actual benefits of applying forecast information, as a percentage of farmers' actual harvests. In the villages where we were working, farmers did not typically sell much if an of their harvest, and we did not compute a monetary value for the additional harvest, because we did not feel this would be a valid measure of the added food security obtained. In theory, however, this would be east to do from our data. As to the second, we showed that a communication strategy in which scientific knowledge is matched with indigenous knowledge can be successful. In all of our workshops, we asked farmers to elucidate their indigenous knowledge, in terms of predictions for the coming growing season. We did not analyze these rigorously, although we did observe a high degree of correspondence. However, by respecting farmers' traditional knowledge, we increased their acceptance of the scientific forecasts as a type of knowledge similar to their own. Farmers suggested to us that this helped in their understanding the forecasts as imperfect predictions, much as their own indigenous forecasts are. Third, we advanced the understanding of communicating uncertain information. We showed that farmers were able to make decisions on the basis of information that contained uncertainty. Our workshops included a great deal of attention to explaining the probabilistic tercile forecasts as prepared by meteorologists, and indeed it was this information that farmers used. We showed that this is possible, provided one takes time to do so well. Moreover, we showed that trust in the probabilistic forecasts was higher than in the deterministic ones heard via the radio.

Suggestions for future research

The main direction of future research that we suggest is in exploring how to implement the forecast workshop program on a wider and more sustainable basis. Farmers in our villages expressed the opinion that would like to see the workshops continue. They formed local committees to work on this, although to date it does not appear that the workshops have continued on in our absence. It would be useful to see whether the extension service would be capable of implementing more timely communication of forecast information, i.e. bypassing their usual procedures for information flow in order to get the forecasts to the farmers quickly enough. It would also be useful to see whether farmers would be able, with some initial assistance, to

organize a series of workshops themselves, in such a way that they would be regular and sustainable. For this research, it would be useful to develop a closer collaborative relationship either with the government extension service, or with NGOs that could play a prominent role, such as the Red Cross.

The other direction for future research is to see whether the same results hold in other countries, with different growing conditions. It could be that forecasts are especially useful for maize agriculture, and less useful for livestock management and the growing of other crops, which are perhaps less drought sensitive. On the other hand, it could be that farmers find ways of including additional information at the margins of their preexisting decisions, no matter what those decisions are. If this is the case, then we would be able to see similar results in other countries. For this, it would be necessary to develop baseline relationships with other national governments.

V. GRAPHICS

Overall approach

We do not have a graphic depicting the overall project approach, nor do we feel that such a graphic is in this case useful, because it would limit us to two dimensions, where indeed the project was carried out to maximize variance on several dimensions. These included the use of a controlled experiment, the variance across years of the study, the variance across different geographical areas, and the natural variance of different crop types.

Map of Zimbabwe with the four pilot villages